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noon and in the late afternoon. Data will be compared with measurements taken by the "A-train," or Afternoon Constellation, which is a fleet of orbiting satellites that pass over California daily every afternoon. "The A-Train satellites have been useful in giving us a broader view of air pollution than we've ever had before," says Kenneth Pickering, Discover-AQ's project scientist at NASA's Goddard Space Flight Center in Greenbelt, Md. "Discover-AQ will help scientists interpret those data to improve air-quality analysis and regional air quality models."

High above the King Air altitude, NASA is also flying one the agency's two U-2 derivative Lockheed ER-2 aircraft on a mission to test three different polarimeters to measure aerosol and cloud properties. A polarimeter gauges the intensity and polarization of reflected light, and is therefore crucial to analyzing the composition of droplets or ice crystals in clouds that impact Earth's radiation budget and climate.

The Polarimeter Definition Experiment will test the three instruments mounted in pods under the wings of the ER-2 as a preliminary evaluation before selecting instruments for the upcoming Aerosol-Cloud-Ecosystem (ACE) satellite. "Each have different engineering realizations on how you might do this," says ACE science lead David Starr of Goddard. "All three have different ways of measuring. They're all multi-angle and frequencies, but how many angles, do you do swathe sampling, what channel should you really polarize?

"There are people who can argue strongly it should be this or that way, So we now have three airborne instruments that express these different concepts. But to go forward with a satellite concept we have to be darn sure it is going to work. It may not be any of these, but we need to prove them out," says Starr, who cautions: "It is not a shoot-out at this point. We are collecting data to enable each to progress toward these goals."

The three instrument teams include New York-based NASA Goddard Institute for Space Studies heading the Research Scanning Polarimeter, NASA's Pasadena, Calif.-based Jet Propulsion Laboratory heading the Airborne Multi-angle Spectro-Polarimetric Imager (AirMSPI); and the University of Maryland heading the Passive Aerosol and Cloud Suite (PACS) polarimeter portion. Although the 65,000-ft. test altitude of the ER-2 is well below that of a satellite, it does provide a repeatable test environment, says Starr who adds that the "ER-2 is in some respect more challenging than the space environment. There are more vibrations and it gets wet every time you come down. We know how to build satellite instruments, right now we've got to make sure we build the right one."

The timing of the parallel Discovery-AQ mission was a fortunate coincidence, adds Starr.

"The P-3 is measuring a lot of things we are interested in so they are a perfect match. We're trying to look at remote data and they are much more in-situ. So we are very willing to work closely with them. A big part of the air pollution out here is particulate (aerosols) and that is what we are interested in. [So we] set up flights overhead so we can be in the same neighborhood."

A third high-altitude mission running in parallel is the Airborne Tropical Tropopause Experiment (Attrex) which is using a NASA Northrop Grumman Global Hawk unmanned air vehicle to make an unprecedented exploration of the tropopause. This is the boundary between the troposphere and stratosphere, ranging from about 8-11 mi. above the Earth's surface, depending on latitude. It marks the boundary where water vapor, ozone and other gases enter the stratosphere. "It's an extremely cold part of the atmosphere and is a 'cold trap' where water vapor condenses into ice crystals," says Eric Jensen, Attrex principal investigator at NASA's Ames Research Center at Moffett Field, Calif.

"Water vapor is a powerful greenhouse gas, and so even a small increase in stratospheric humidity will warm the surface. We have recognized that it is very important for us to understand it and to make sure that our climate models are seeing it correctly," Jensen adds. As changes in stratospheric humidity may have significant climate impacts, these predictions are becoming more important. Yet modeling remains uncertain because the physical processes occurring in the tropopause are not fully understood. Under Attrex, NASA will use the high-altitude capability of the UAV to carry instruments via a variety of profiles through this layer near the equator off South America.

The Global Hawk is configured with 12 instruments to measure cloud properties such as ice crystal size and water vapor concentrations in addition to trace gases and temperatures above and below the aircraft. It will also monitor meteorological conditions, radiation fields and chemical traces, "which tell us about the transport processes," he adds.

An initial six science flights, each lasting 24 hr. or more, are planned for completion by March. Additional remote deployments to Guam and Townville, Australia, are on the 2014 agenda. ❂

Space Sailplane

NASA scaled glider tests could hold key to lowering launch costs to space

Guy Norris Edwards AFB, Calif.

As the development of Stratolaunch's Air Launch and Scaled Composites' WhiteKnightTwo carrier aircraft shows, the use of wing-borne platforms for delivering rockets to orbit is set to grow as the industry strives for lower launch costs.

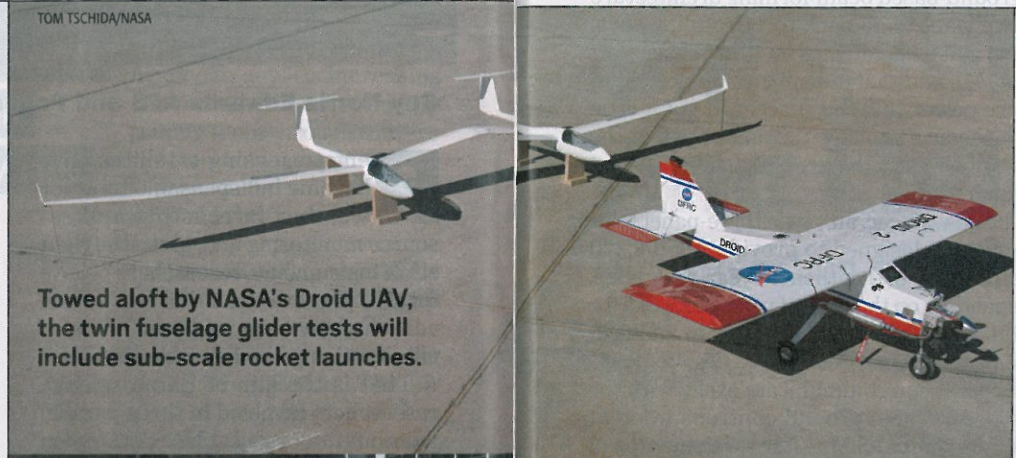
However, unlike the latest purpose-built air launchers, which build on the experience gained over the years of proven mothership vehicles such as the Boeing B-52 and Orbital Sciences' Lockheed L-1011, a newly unveiled NASA air launch concept differs in one major aspect in that it has no engines.

The agency is preparing to flight-test a scaled version of a towed-glider air-launch concept that it believes has the potential to "dramatically" reduce the cost of launching payloads into orbit. The scheme leverages the additional lifting capacity of a towed, high-aspect-ratio-configured glider to raise the rocket vehicle to an air-launch altitude. Unlike self-powered platforms, the towed glider will be lighter, cheaper and simpler, allowing for relatively heavier payloads, says a NASA Dryden Flight Research Center business development and towed glider project manager, Jerry Budd.

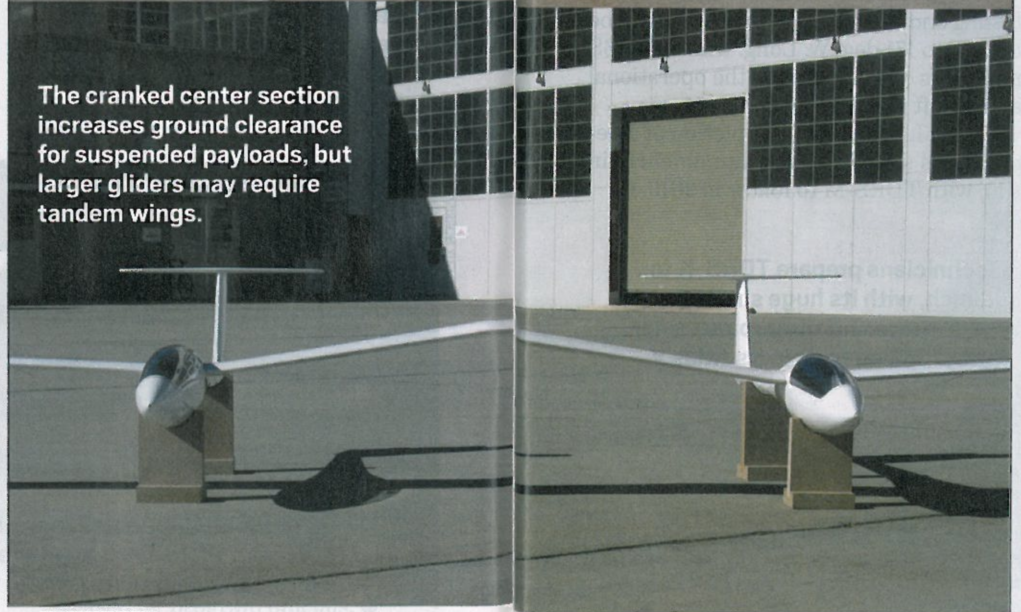
The initial tests will be focused on a 24-ft.-wingspan, twin-fuselage proof-of-concept vehicle developed at Dryden's model shop using two modified, radio-controlled sailplanes. The models are connected with a specially made, cranked, inverted V-shaped center wing section which houses the payload in a similar configuration to WK2. For the tests, Budd says the sailplane will be towed aloft by NASA's Droid (Dryden Remotely Operated Integrated Drone) unmanned air vehicle which was used in last year's flight tests of a miniature automatic ground collision avoidance system hosted in a smartphone.

After a flight to prove the baseline characteristics of the sailplane, the vehicle will be fitted with a 100-lb. sub-scale rocket booster and towed by the Droid to an altitude of 8,000-10,000 ft., where the rocket will be launched. After the rocket has been fired, the glider will release from the tow-line to glide back to the North Lakebed at Edwards AFB, while the Droid would return under remotely piloted control. Budd says details of whether rocket launches from an operational vehicle will take place while under tow or after release, as well as other aspects of the concept of operations, are being worked out and will be evaluated in a second phase.

TOM TSCHIDA/NASA



Towed aloft by NASA's Droid UAV, the twin fuselage glider tests will include sub-scale rocket launches.



The cranked center section increases ground clearance for suspended payloads, but larger gliders may require tandem wings.

GUY NORRIS/AW&ST

Budd says the next step would be a flight evaluation of a full-scale glider using two sailplanes mated to carry a larger 6,000-lb.-class booster. The vehicle would be optionally piloted with "a pilot in the left side. The idea would be to go up to 28,000 ft. without a pressurized cockpit and clear the initial envelope." Next would be a full fly-by-wire flight-control system, unmanned for the full envelope clearance, he says.

The full-scale glider, which would be towed to eventual launch altitudes of around 40,000 ft. by the Proteus or WK2, would be capable of demonstrating the launch of small rockets able to place up to a 100-lb. payload into low Earth orbit. It would also act as a "risk-mitigation" tool, clearing the way for a third phase involving a larger, purpose-designed "X-plane," says Budd.

The 35,000-lb. third-phase vehicle would be built under contract to carry a larger booster in the 80,000-lb. weight class, such as an Orbital Minotaur 1. Towed to launch altitudes above 28,000 ft. by an existing commercial aircraft such as a DC-10, Budd says the combination shows the potential for significant savings. Initial results from three independent reviews of the concept include estimated gains in launch performance of 25-50% for the standard Minotaur 1, and cost savings of 20-33%, says Budd.

As to the pros and cons, Budd says the concept would have greater launch location flexibility and the potential for a performance boost by launching at or near the equator. It would also allow a wider variety of sizes and geometries of launch vehicles to be carried, and could be scalable across a large range. It would enable expanded launch windows, with faster orbit rendezvous and offer lower maintenance and storage costs.

Drawbacks would include increased overhead for the launch operation compared to a crewed carrier air-launch vehicle, and the possible issue of a "hung store." Launch operations could also be more complex than with a crewed vehicle, while cryo-powered rockets would be harder to support.

Test flights of the sub-scale glider, based on two model Ventus-2axs, are expected to begin by late May under initial innovation funding provided by NASA's Office of the Chief Technologist. Further stages would aim to see first flight of the risk-mitigation vehicle at the end of fiscal year 2013, and first flight of the full-scale X-vehicle at the end of fiscal 2015. ❂